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Dated 12 March 2003

Patents Form 1/77

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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

22 JAN 2002

The Patent Office
Cardiff Road
Newport
South Wales
NP9 1RH

1. Your reference

538GB 22JAN02 E689795-1 D02651
700 0.00-0201362.1

2. Patent application number
(The Patent Office will fill in this part)

0201362.1

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Renishaw plc
New Mills
Wotton-under-Edge
Gloucestershire, GL12 8JR

Patents ADP number *(if you know it)*

2691002

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

Reversible Sample Holder

5. Name of your agent *(if you have one)*

M Fowler et al

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Renishaw plc, Patent Department
New Mills
Wotton-under-Edge
Gloucestershire, GL12 8JR

Patents ADP number *(if you know it)*

8276297001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
–	–	–

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*
–	–

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	7
Claim(s)	0
Abstract	0
Drawing(s)	2

10. If you are also filing any of the following, state how many against each item.

Priority documents	0
Translations of priority documents	0
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	0
Request for preliminary examination and search *(Patents Form 9/77)*	0
Request for substantive examination *(Patents Form 10/77)*	0
Any other documents *(please specify)*	0

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 22.01.2002

AGENT FOR THE APPLICANT

12. Name and daytime telephone number of person to contact in the United Kingdom A ILES 01453 524524

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Notes

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Reversible Sample Holder

This invention relates to a reversible sample holder whose location and orientation can be determined. For example. It may be used for the scanning of samples in two stages and matching together the data from the two stages providing coherent information. A preferred form relates to the scanning of dentalware such as frameworks for dentures.

One way that three dimensional samples are scanned involves a stationary sample, a probe having three dimensional movement and styli that can access the whole surface of the sample including the underside enabling the whole surface to be scanned.

A problem with this method is that the equipment used requires a relatively large working space so it is unsuitable for situations where there are size limitations. A solution to this problem is to rotate the sample during the scanning process as this reduces the number of degrees of freedom that the probe requires. However, this solution results in further problems when scanning samples which have undercuts as this can lead to incomplete scans. Different problems are encountered when elongate samples, such as bridges, are involved.

The present invention provides a device for locating the position and rotation of a reversible sample holder comprising a reversible sample holder; and a plurality of reference points characterised in that the reference points each provide positional and rotational information about the reversible sample holder.

Preferably, the device further comprises a base wherein the reversible sample holder is adapted on two opposite sides to co-operate with the base.

This enables the approximate location of the sample holder and thus an attached sample to be established without use of the reference points.

Preferably, the reference points are provided by a block of material of known dimensions and having machined faces which adjoins the sample holder.

In a preferred embodiment, the reference points are only be provided by surfaces which are commensurately larger than a device used to locate the surfaces in space (a probe or laser, for example) whereas the sample holder must be of sufficient size to hold and/or support a sample. If the reference points are on such a block of material, machining costs are reduced. This is because the sample holder does not have to be machined to the same degree of precision as it would have been to provide the reference points.

Preferably, the reversible sample holder co-operates with the base using a kinematic mount. This ensures that when the sample holder is reversed, the position of an attached sample and the reference points will be at substantially the same location as the opposite side was prior to inversion of the sample holder.

According to a second aspect of the present invention, there is provided a device for scanning a sample in two stages comprising

a base;

a reversible sample holder adapted on first and second sides to co-operate with the base, the first and second sides being opposite each other;

a plurality of reference points providing positional and rotational data about the first and second sides of the reversible sample holder; and

a scanning system

characterised in that the plurality of reference points provide positional and rotational data about the first and second sides of the reversible sample holder enabling the two stages of a scan to be joined or matched.

According to a third aspect of the present invention there is provided a method of scanning a sample in two stages comprising the steps of

providing a base;

locating a reversible sample holder on the base;

referencing a plurality of reference points providing three dimensional rotational and positional data about the sample holder;

scanning a first part of a sample held in the sample holder;

reversing the sample holder with respect to the base;

referencing a plurality of reference points providing three dimensional rotational and positional data about sample holder in the reversed position;

scanning a second part of a sample held in the sample holder; and

matching the scans of the first and second parts of the sample using the reference points producing a complete scan of the sample.

Preferably the sample is a tooth framework.

According to a fourth aspect of the present invention there is provided a method of scanning a sample in two stages comprising
providing a base;
locating a reversible sample holder on the base the reversible sample holder being adapted on first and second sides to co-operate with the base, the first and second sides being opposite each other;
providing a plurality of reference points capable of supplying three dimensional rotational and positional data about the first and second sides of the reversible sample holder; and
furnishing a scanning system;
characterised in that a first scan is made by the scanning system when the first side of the reversible sample holder co-operates with the base and a second scan is made when the second side of the reversible sample holder co-operates with the base and the two scans are matched together using the positional and rotational information provided by the reference points.

The invention will now be described by example with reference to the accompanying drawings, in which:

Figure 1 shows an isometric view of a scanning apparatus using a device according to the invention.

Figure 2 shows an isometric view of device according to the invention.

Figures 1 and 2 show a device 1 having a base 2 with a

support surface 3. A reversible sample holder 4, is T-shaped and has three ball bearings 5, 6, ,7 embedded in both its upper surface and in its lower surface (not shown). One ball bearing is disposed near each end of the 'T' on each side. A cube 8 is adjoined to the reversible sample holder 4 and has four machined faces 9, 10, 11, 12 which provide reference points. A tooth framework 13 is secured to the sample holder 4 via removable end pieces 14, 15 which are secured by screws 16, 17 to each end of the top of the 'T' of the sample holder.

The tooth framework 13 is attached to the sample holder by at least partially removing the screws 16, 17 that hold the end pieces 14, 15 to the sample holder and inserting the ends of the framework 13. When the screws 16, 17 of the end pieces 14, 15 are tightened, the framework is held in position.

The reference points on cube 8 and the framework 13 are scanned by a contact probe 22. An alternative scanner would be a laser probe.

Referring now to Figure 2, the support surface 3 has a magnet 18 disposed at its centre and three v-shaped grooves 19, 20, 21 lying radially spaced 90° apart (thus forming a 'T' shape). The three ball bearings 5, 6, 7 in each side of the reversible sample holder 4 are disposed so that one lies vertically above/below another thus, each set of three balls co-operates with the three v-shaped grooves 19, 20, 21 in the support surface 3. This means that when the sample holder is reversed with respect to the base, the sample holder and thus the sample held therein are located in

substantially the same place.

It will be appreciated that the grooves 19, 20, 21 and balls 5, 6, 7 form a (slightly degenerate) kinematic mount. Kinematic mounts of various types are well known, and described in (for example) HJJ Braddick, "Mechanical Design of Laboratory Apparatus" Chapman and Hall, London, 1960. Other kinematic mounts (and quasi-kinematic or partly degenerate kinematic mounts) may be used instead.

In order to obtain a complete scan of the surface of the framework 13, the framework is secured to the sample holder 4 as described above. The sample holder 4 is then placed on the support surface 3 in an orientation such that each ball bearing 5, 6, 7 co-operates with a groove 19, 20, 21. The magnet 18 ensures that this position is maintained until the sample holder 4 is removed from the base 3. Three of the reference surfaces 9, 10, 11 (one to determine the position of the reference block in each dimension) are scanned followed by the upper portion of the framework 13. Once this first part of the scan is complete, the sample holder 4 is reversed with respect to the base 3. Three reference points 10, 11, 12 are again taken this time however, the reference point for the vertical position is taken from a different face of the reference block 8 as the sample holder 4 is now reversed compared with its original position. The lower portion of the framework 13 is now scanned.

The reference block 8 is accurately machined so that each face is perpendicular to the adjacent faces. The distance between each set of opposite faces of the

block needs to be known or measured (preferably under the same conditions as the framework scan). The reference points taken for each part of the scan in conjunction with distance between the opposite faces of the block can then be used to match the two stages or parts of the scan (using appropriate computer software) adjusting said scans to take in consideration differences in the height and rotation of each part scan resulting in a complete matched scan of the framework.

Figure 1

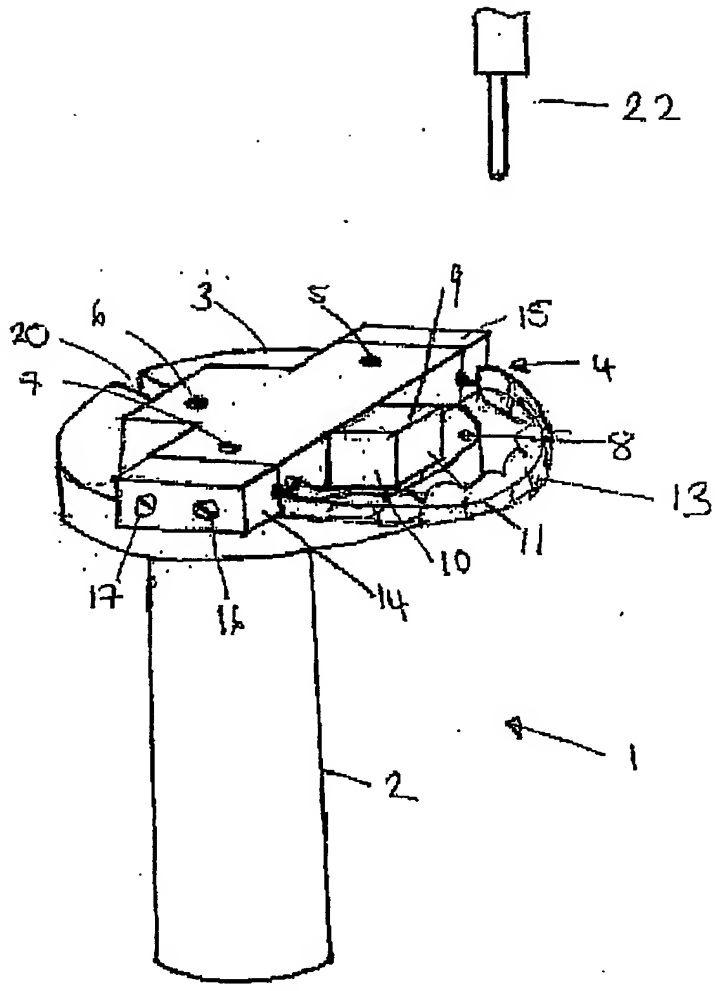

Figure 2